Climate change and the wicked problem of wildfires

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Context

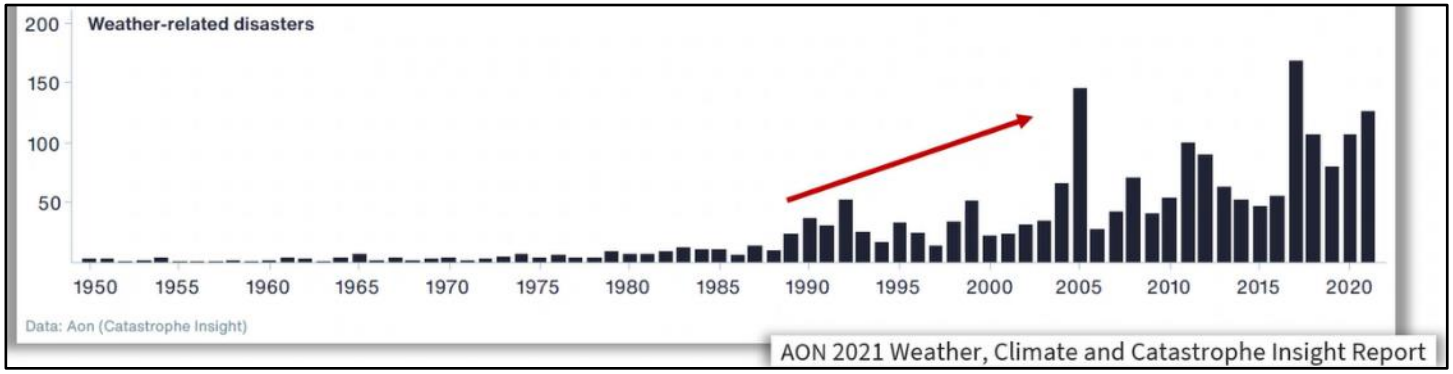
The Global Risks Report 2022

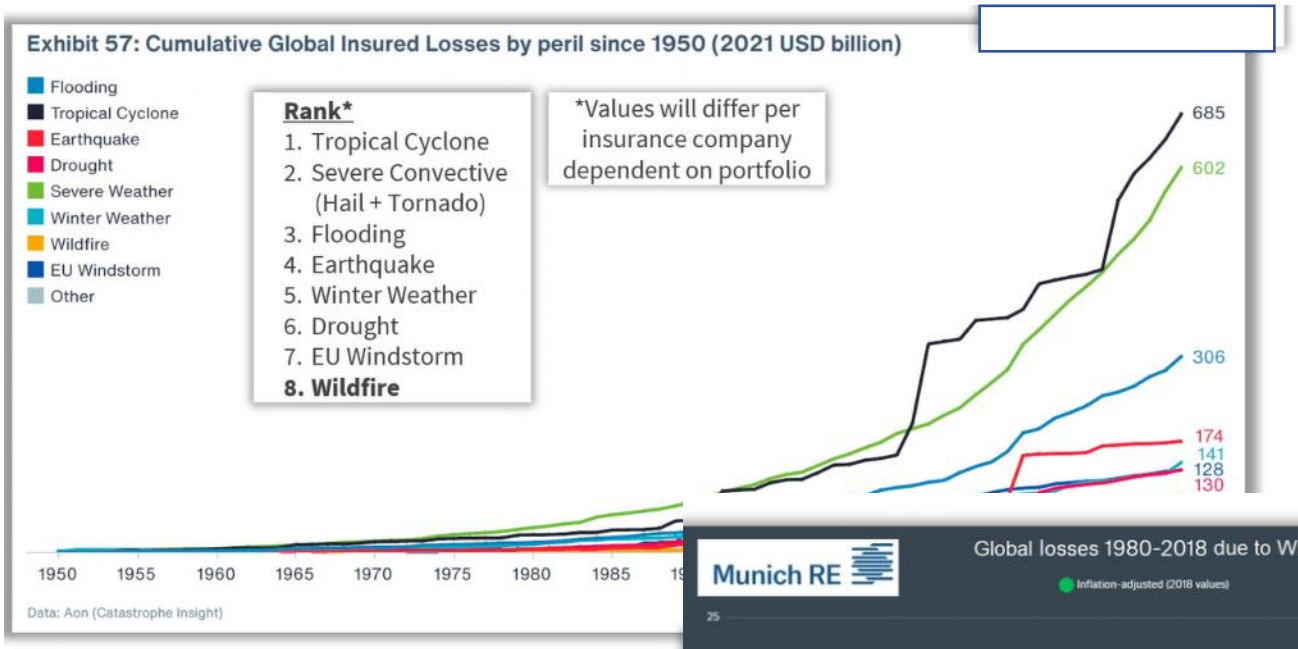
‘Over a 10-year horizon … environmental risks are perceived to be the five most critical long-term threats to the world.’

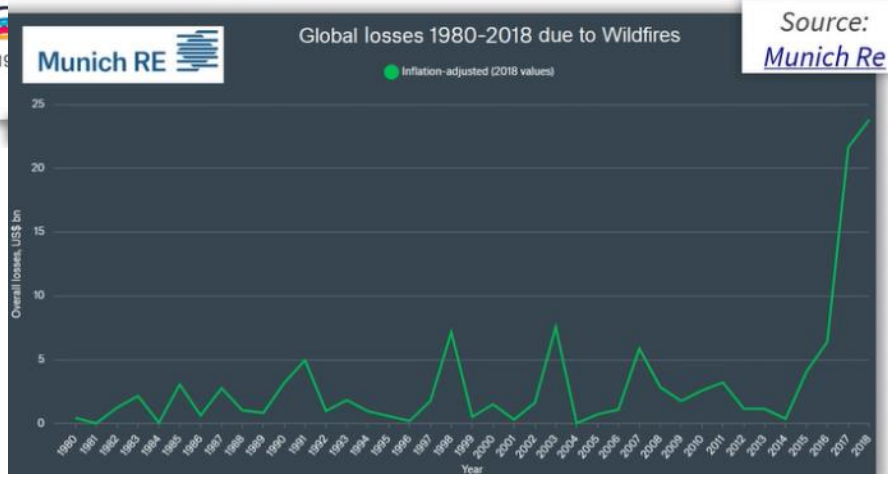
‘“climate action failure”, “extreme weather”, and “biodiversity loss” rank as the top three most severe risks.’ (World Economic Forum)

‘US wildfire should no longer be treated by re/insurers as a secondary peril, following a 30% rise in the number of major wildfires over the last 15 years.’
(Reinsurance News, August 2021)

‘While the science is still at an early stage, the insurance industry can’t afford to wait and see. The number of wildfires and heatwaves tells us something is happening.’
(Lucia Bevere, Senior Catastrophe Data Analyst, Swiss Re Institute, 2020)







US$ 25bn

Global wildfire losses 2019-2021, with insurers paying out a total of US$ 17bn

Overview

Introduction to fire

1. What is fire?
2. Ecological effects of fire

Case studies

1. The Mediterranean Basin
2. Australia
3. The Amazon

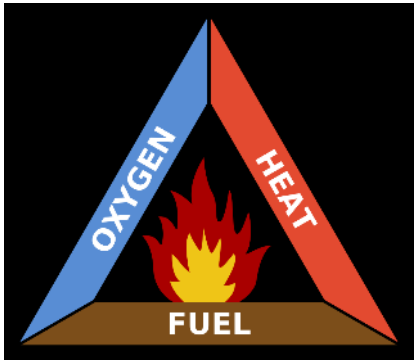
Why a wicked problem?

What is fire?

Fire is a rapid chemical oxidative reaction that generates heat, light and produces a range of chemical products.

What does fire need?

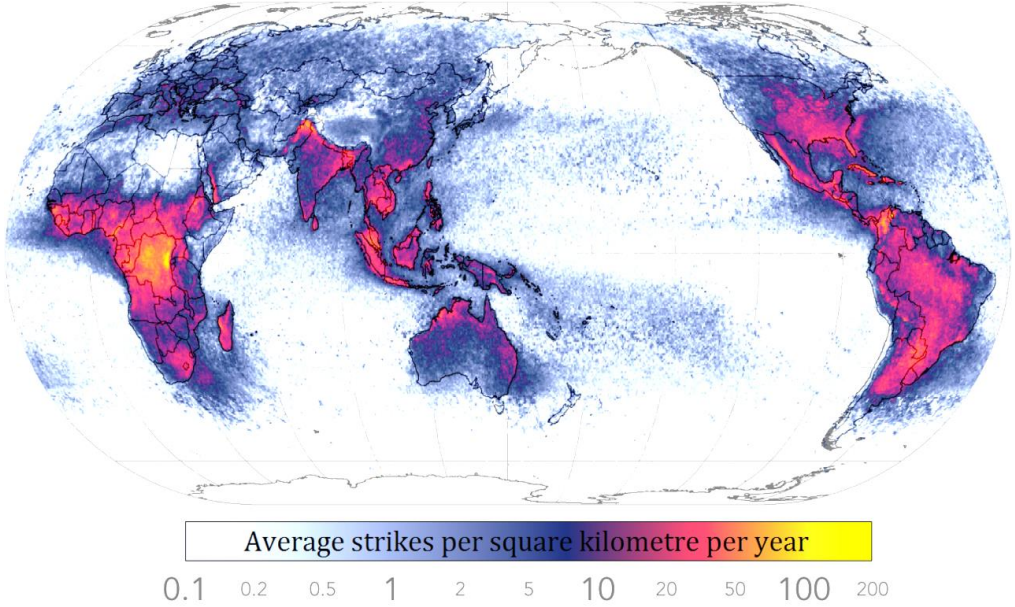
- An ignition source
- Dry fuel
- Oxygen



The Fire Triangle
(credit: Gustavb 2006)

Lightning (Credit: Tillman 2016)

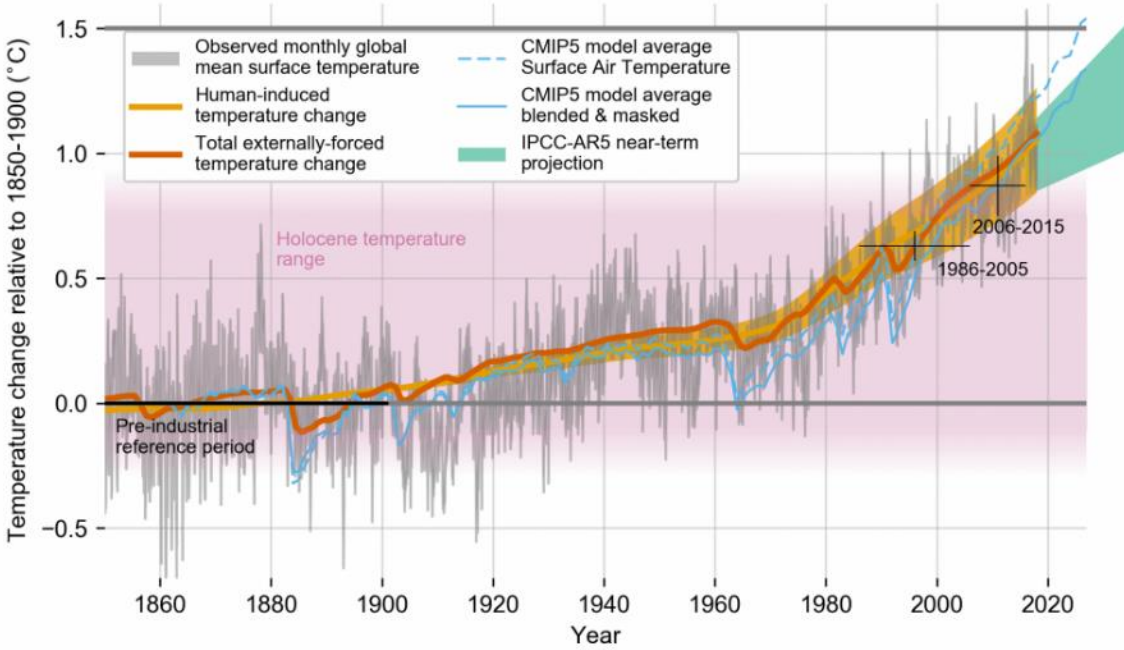
Below: global frequency of lightning strikes
(credit: Citynoise 2008, from NASA)



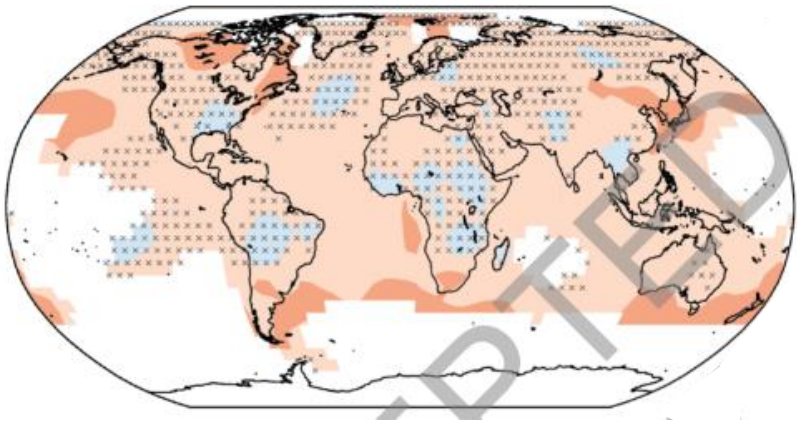
IPCC AR6

WG1:Observations
Temperature

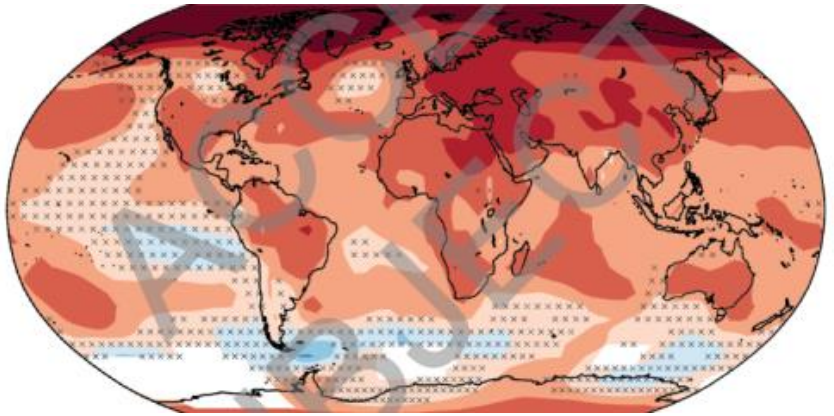
Each of the last four decades has in turn been **warmer at the Earth's surface** than any preceding decade since 1850



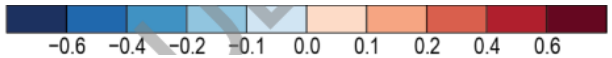
1900-1980



1981-2020



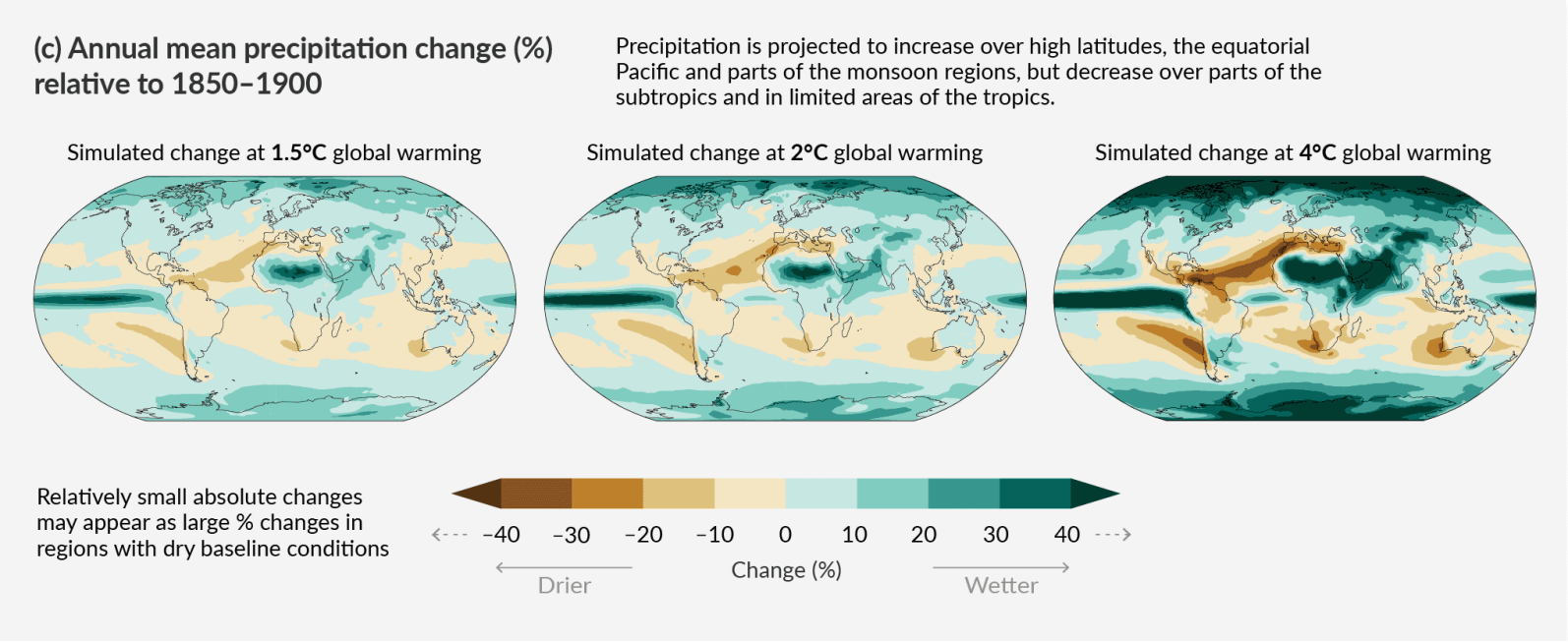
Trend (°C per decade)



WG1 Observations: Change in annual mean **precipitation**

Averaged over mid-latitude land areas of the Northern Hemisphere, **precipitation** has increased since 1901. The **frequency** & **intensity of heavy precipitation events has increased.**

Changes in many **extreme weather and climate events** have been observed since c.1950.



WG1: Observations: **Wind speed**

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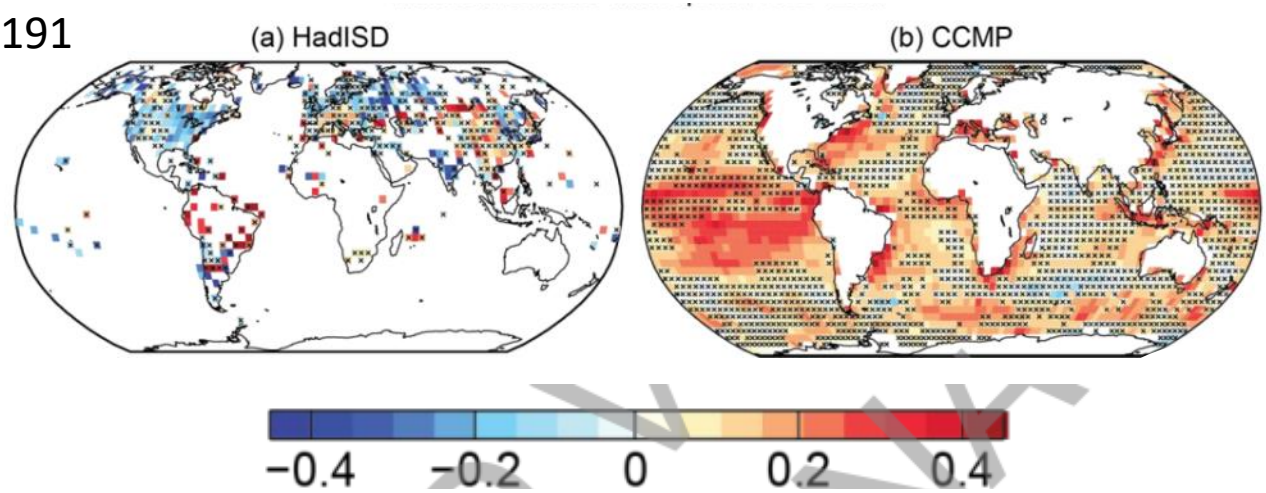


Trends in surface wind speed 1988-2017 (ms^{-1} per decade)

WG1: Observations (AR6)
Atmospheric **CO_2 concentrations**

Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to unprecedented levels

Credit: University Corporation for Atmospheric Research UCAR

Mauna Loa Observatory

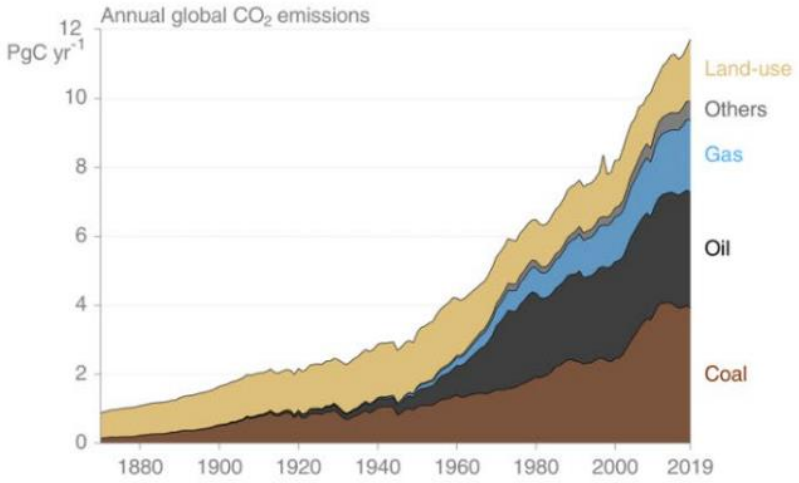
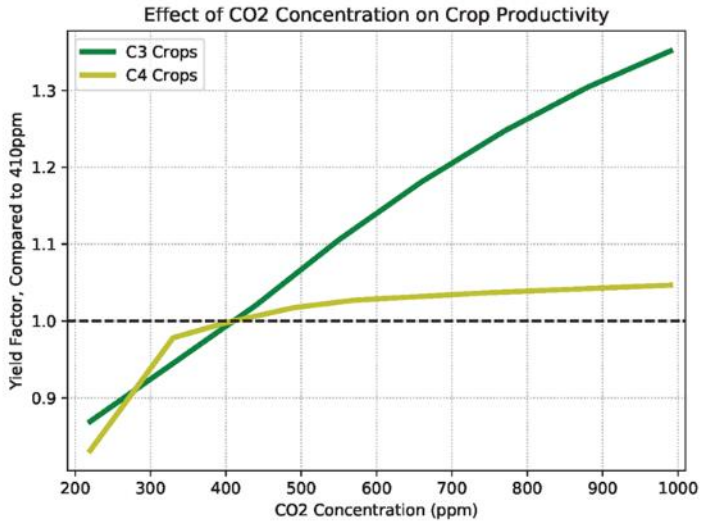


Figure 5.5: Global anthropogenic CO_2 emissions.



IPCC AR6 ch.5

What does a vegetation fire do?

Fire consumes all vegetation types, like a generalist herbivore.

Fire produces

inorganic ash and charcoal

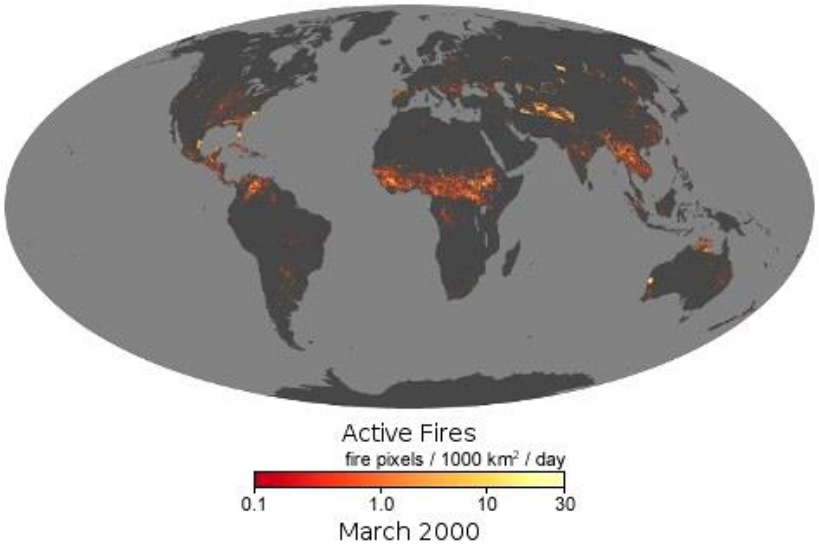
volatile chemicals and compounds (aerosols)

- both kinds of products can have significant environmental impacts.

Kinds of fires

Surface or ‘brush’ fire
Spreads through low lying vegetation, trees unaffected.

Fire regimes



Fire regimes are an amalgam of the following aspects of fires in landscapes over time:

- fire spread patterns,
- fire intensity,
- the size and distribution of fire patches,
- fire frequency and seasonality.

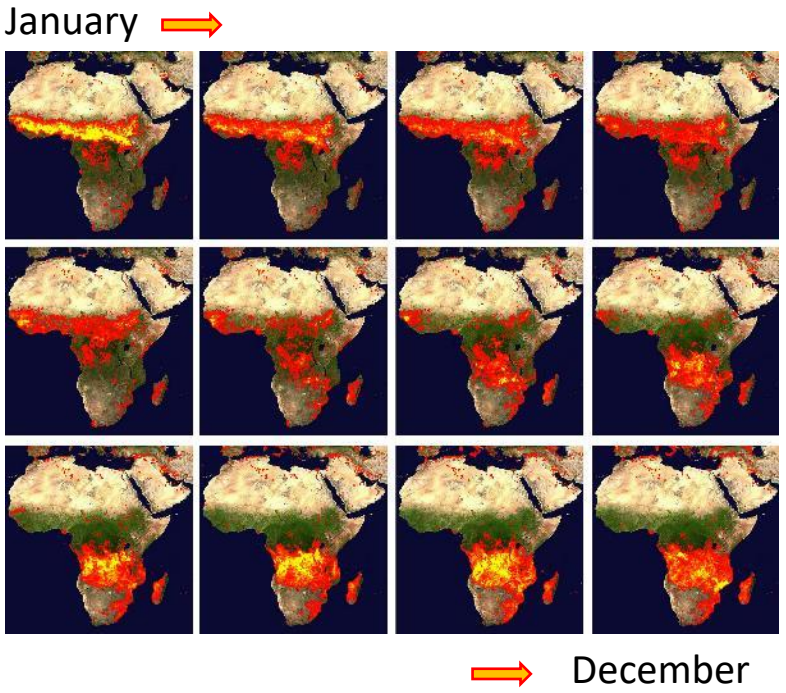
Fire severity is influenced by

Wind speed

Temperature

Humidity

Fuel type and condition (dryness)

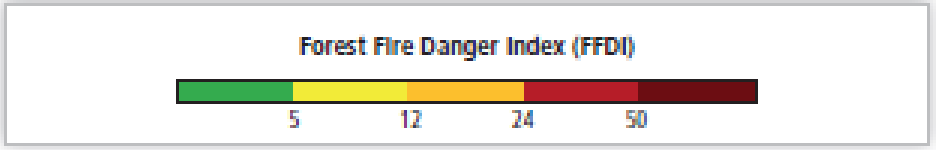


Disturbance regimes

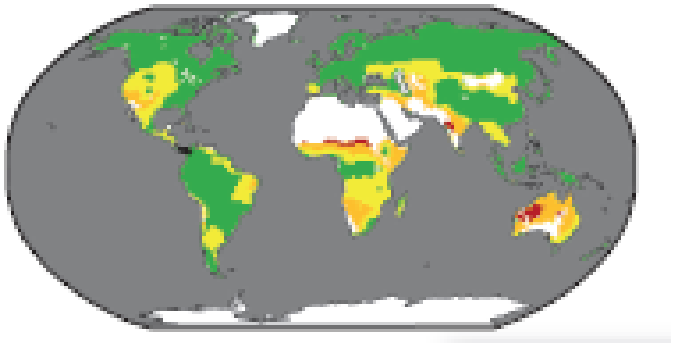
Disturbance regime = the totality of different types of disturbance events in a system, each characterized by its:

- probability of occurrence,
- intensity, and
- other relevant attributes e.g. seasonal pattern.

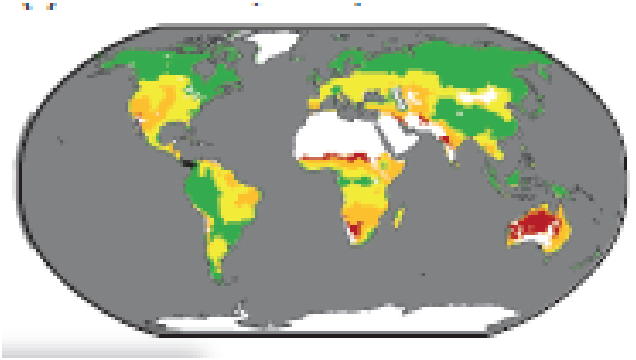
Change in the **fire disturbance regime** is a key early indicator of terrestrial ecosystem change.



FFDI 1970-99



FFDI 2070-99



Mediterranean fire regimes

Mediterranean climates provide ideal fire conditions. The Mediterranean region of Europe is warming and drying and fires are becoming more intense and difficult to control.

Fire regimes are also changing due to **rural depopulation** and **land abandonment** along with reduced livestock grazing pressure. Old abandoned fields become more shrubby. Some are planted up with pines and eucalypts, with heavy fuel loads.

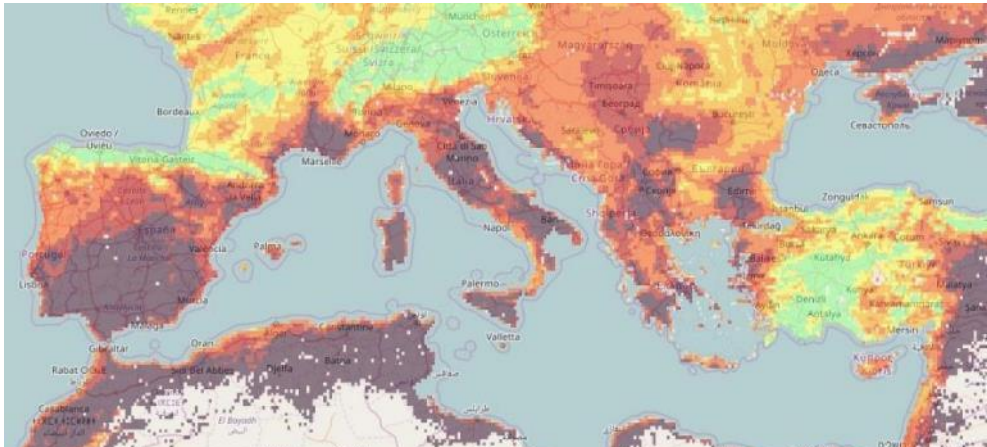
Prescribed burn, Portugal

Some **imported shrubs and trees** are better adapted to post-fire recovery, invading local ecosystems. All burn more intensely than the indigenous vegetation.

Coastal **development in response to tourism** has increased the wildland-urban interface, and fire ignitions.

Urban-oriented fire brigades have replaced forestry departments, lacking fire prevention or fire fighting skills. Prescribed block burning is unpopular and sporadic.

Below: Fire Danger Forecast for the Mediterranean, summer 2017 (Global Wildfire Information System)



The 2019-20 Australian bushfires

More than 12.6 million hectares (126,000 sq km) of bush, forest and parks burned

33 people were killed

c.2,500 homes were torched

Hazardous air quality: c.430 tonnes of CO_2 emitted, smoke spreading as far as South America.

Destroyed homes in Hillville, NSW.
(Credit: Raginginsanity 2019)

Biodiversity

Millions of animals killed; 3 billion affected

Credit: Jimboomba Police

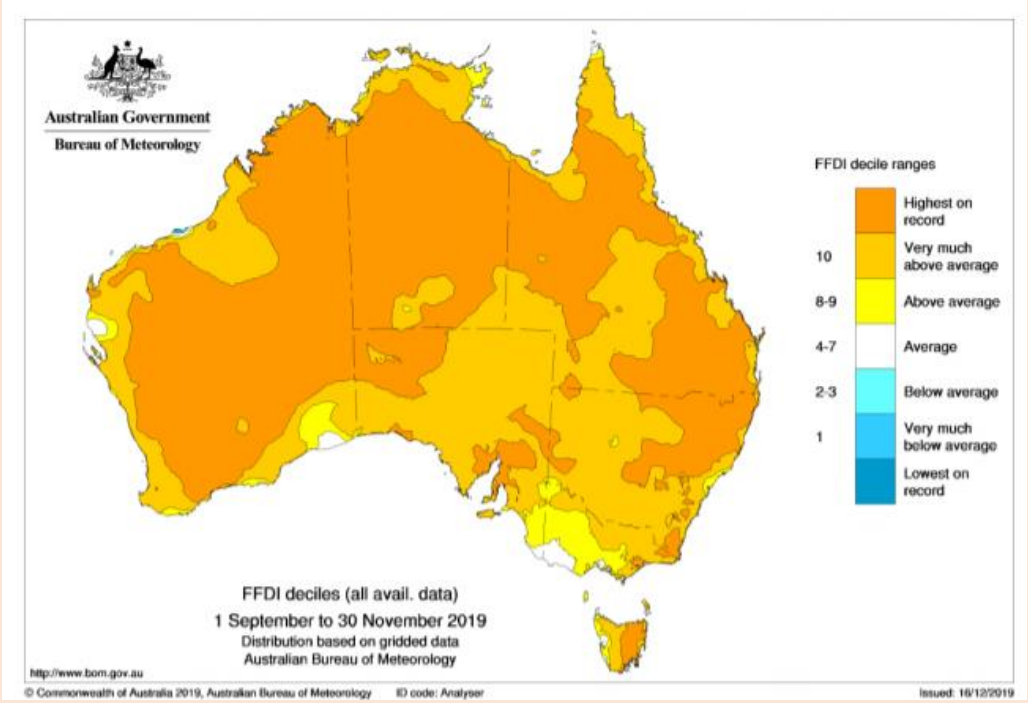
Bushfire smoke over Sydney harbour
(credit: Nick-D 2019)

Social and ecological causes

Anthropogenic causes

Arson and accidents

Management & policy
Poor building standards and zoning
Climate change denialism influencing policy



Natural Causes

Hotter and drier climate = more frequent and intense fires
Hotter temperatures and prolonged drought made it easier for the fires to spread and grow

Fire Weather
>95% of Australia had Forest Fire Danger Index (FFDI) values above average, with c.60% of Australia with highest on record.

Bush fires drive thunderstorms
Big fires create their own weather, creating thunderstorms and lightning strikes

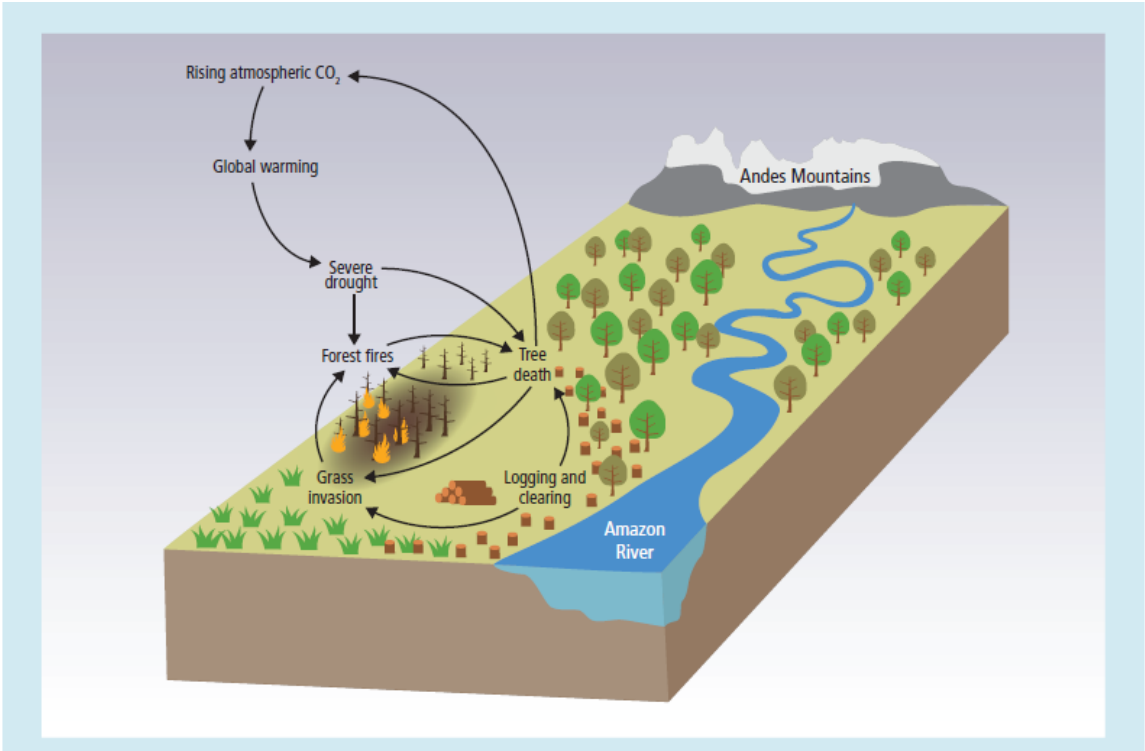
Will the Amazon kindle?

Sea surface temperature increases in the tropical North Atlantic are causing more frequent **severe drought** episodes in the Amazon region.

Tree mortality in the Amazon is increasing through drought and increased **forest fire occurrence**

Fire risk is exacerbated by land use: logging and clearing for beef and soy farming, causes habitat fragmentation, allowing in grasses and fires

Severe drought episodes, land use, and fire **interact *synergistically*** – driving the transition of mature Amazon forests to fire-adapted savanna vegetation.



So, why is fire a wicked problem?

A wicked problem avoids straightforward articulation and is impossible to solve in a way that is simple, universal or final.

Climate Change is a multidimensional social-ecological phenomenon characterised by uncertainty, complexity, variability and disagreement.

So is wildfire: people understand it in different ways, manage it in different ways, to avoid or achieve different goals.

Major fire policies are shaped by colonial-era assumptions, narrow sectoral goals, and outdated fire science.

Fire interacts in complex ways with climate, vegetation, herbivores and human land use.

The many drivers shaping fire regimes include

Intensification of fire weather, longer fire seasons

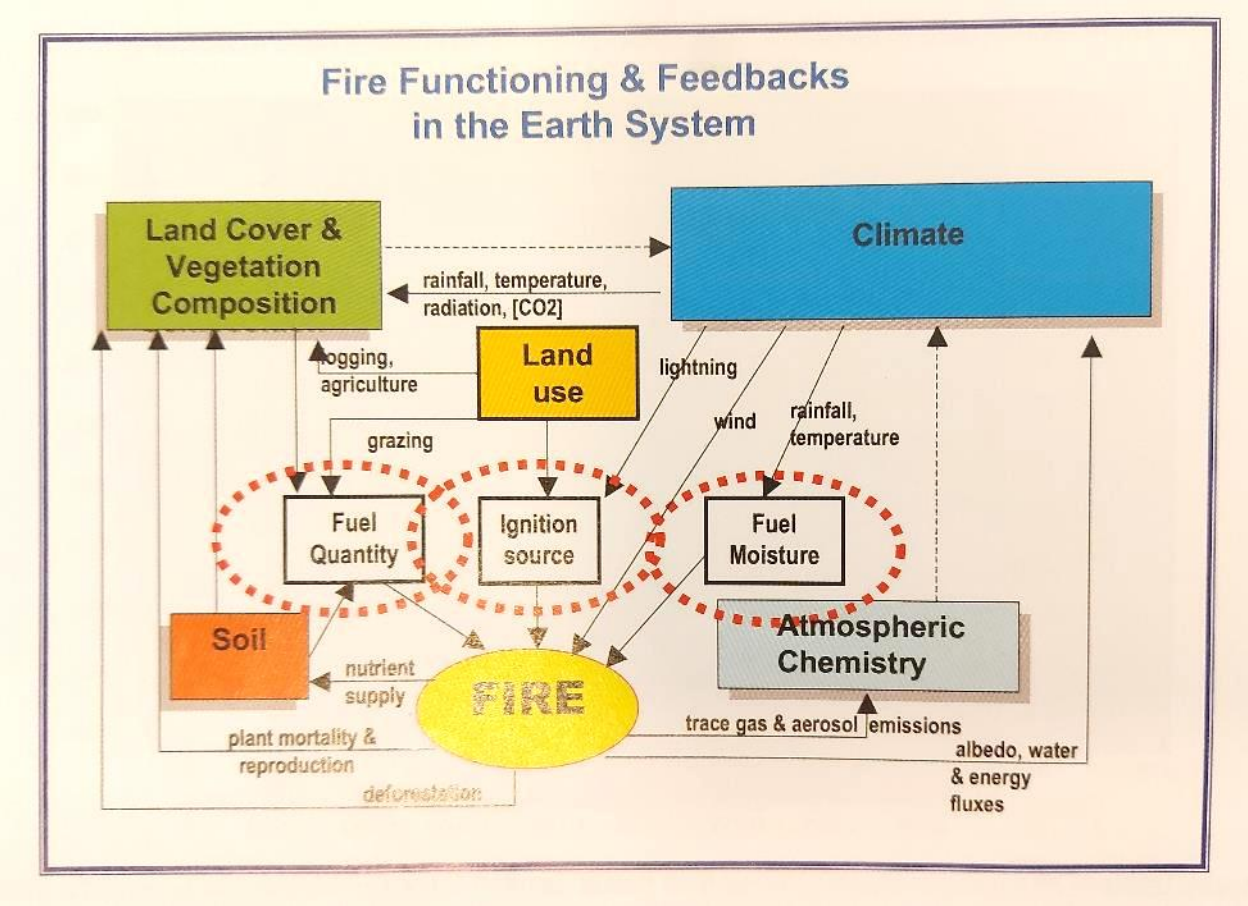
Increasing CO_2 levels

Invasive alien plants and introduced inflammable plants

Synergies between climate change, human land use, and vegetation change

Rural land abandonment, and contrariwise, urban sprawl

Burning practises, and policies, which vary widely within and across regions.



Scott et al. (2014) *Fire on Earth* 42

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